

REMARKS

Claims 1-15 are pending in the application.

Claim 16 has been canceled. Claim 1 has been amended to recite that component (B) is present in an amount of 0.5 to 20 volume %. Support for this amendment may be found in the specification at least at page 13, lines 3-6. No new matter has been added by these amendments, and entry is respectfully requested.

In the present Office Action, the Examiner has rejected claims 1-9, 12, 13, and 15 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent Application Publication No. 2003/0118913 of Takami et al. ("Takami") in view of U.S. Patent No. 6,315,918 of Mita et al. ("Mita"). The Examiner has rejected claims 10-11 under 35 U.S.C. §103(a) as being unpatentable over Takami in view of Mita and further in view of EP 0796510 ("EP '510"). Further, claims 14 and 16 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Takami in view of Mita and further in view of U.S. Patent Application Publication No. 2001/0018152 of Kida et al. ("Kida") or U.S. Patent No. 6,090,506 of Inoue et al. ("Inoue"). Finally, claim 15 has been rejected under 35 U.S.C. §103(a) as being unpatentable over Takami in view of Mita and further in view of U.S. Patent Application Publication No. 2002/0001756 of Hamamoto et al. ("Hamamoto"). Applicants respectfully traverse these rejections and the arguments in support thereof for the reasons set forth previously on the record, which Applicants rely upon in full, and for the additional reasons which follow, and respectfully request reconsideration and withdrawal of the rejections.

Rejection Under §103(a) Based on Takami in view of Mita

Regarding claims 1-9, 12, 13, and 15, the Examiner again argues that Takami teaches a non-aqueous electrolyte secondary battery comprising an electrode group containing a positive electrode, a negative electrode and a non-aqueous electrolyte including solvents and lithium salts dissolved therein. It is allegedly disclosed to use cyclic carbonates, such as ethylene carbonate, propylene carbonate, or vinylcarbonate, together with γ -butyrolactone, and further to be desirable to prepare a mixed solvent including an aromatic compound. Various preferred combinations of non-aqueous solvents are allegedly taught, particularly in paragraphs [0057]-[0059] and in Examples 15-18.

Regarding claims 12-13, the Examiner argues that Takami discloses the claimed positive and negative electrode materials and the employment of lithium salts, such as LiPF_6 and LiBF_4 ,

as recited in claims 14 and 16. Finally, the Examiner argues that Takami teaches in paragraph 63 a solvent containing a benzene-like or derivative compound, as well as a specific solvent mixing solution in Example 14. For these reasons, the Examiner concludes that Takami discloses a non-aqueous electrolyte secondary battery. The Examiner acknowledges that Takami does not disclose the specific use of vinyl ethylene carbonate (VEC) solvent as claimed.

However, the Examiner argues that Mita discloses non-aqueous electrolytic solutions employed in the electrochemical field and specifically teaches that organic solvent-based electrolytic solutions (non-aqueous electrolytic solutions) show a high potential window of electrochemical stability. Mita allegedly discusses secondary batteries. The Examiner further argues that Mita teaches that cyclic carbonic esters can be suitably used as a solvent for the electrolytic solutions used in batteries; the solvents may be used singly or in combination and include ethylene carbonate, butylene carbonates, vinylene carbonate, and cyclic esters such as γ -butyrolactone, 3-methyl- γ -butyrolactone and 2-methyl- γ -butyrolactone. In particular, Mita allegedly exemplifies the use of VEC in a mixed solvent.

Accordingly, the Examiner concludes that it would have been obvious to one having ordinary skill in the art at the time of the invention to use the VEC solvent of Mita in the secondary battery of Takami because Mita teaches that the cyclic carbonic esters can be suitably used as a solvent for the electrolytic solutions used in batteries, since such solvents show excellent acid resistance, are not oxidized when allowed to stand in the atmosphere, and are chemically stable without reacting with water under normal storage conditions or reacting with highly reactive substances such as metal lithium. In addition, such cyclic carbonic esters are allegedly physically safe, not readily thermally decomposed, and are flame-retardant and resistant to electrochemical oxidation or reduction. Furthermore, the Examiner notes that Mita and Takami share the same field of endeavor of providing suitable non-aqueous electrolytic solutions for electrochemical applications or resistance to electrochemical oxidation-reduction. Therefore, the Examiner concludes that both references are relevant to each other. Finally, since Takami allegedly teaches the use of cyclic carbonic acid esters having at least one carbon-carbon unsaturated bond in a combination of mixed solvents, the Examiner concludes that one cyclic carbonic acid ester can be used interchangeably to substitute for another because they are deemed to be functionally and chemically equivalent.

Finally, the Examiner contends that Applicants' previous arguments that the prior art does not demonstrate the unexpected results exhibited by Applicants' invention, specifically for the inclusion of VEC and the specific molar ratios of the combined lithium salts, are not persuasive. Specifically, the Examiner argues that the data which were presented are not commensurate with the claims, noting for example that reduction of the amount of gas generated (as shown in Example 5 and Tables 12-13) is achieved only using 1% VEC, and not shown for the entire claimed concentration of 1 to 99%. Similarly, the Examiner contends that the data of the Ueda Declaration do not evidence unexpected results for the entire claimed LiBF_4 to LiPF_6 molar ratio of 1:9 to 9:1 because there is no significant difference between the claimed molar ratio and the unclaimed molar ratio, as evidenced by the capacity maintenance rate, nor were any unexpected results shown for the entire claimed range of 1:9 to 9:1, as evidenced by the cycle life or the amount of gas after cycles. Applicants respectfully traverse this rejection as follows.

As noted above, Applicants rely in full on the arguments submitted in the Amendment filed June 17, 2004 and these arguments will only be summarized for the Examiner's convenience. The present invention is directed to a non-aqueous electrolyte secondary battery which contains a non-aqueous solvent containing (A) a cyclic carboxylic acid ester; 0.5 to 20 volume % of (B) a cyclic carbonic acid ester having at least one carbon-carbon unsaturated bond; and (C) a cyclic carbonic acid ester having no carbon-carbon unsaturated bond. Component (B) comprises vinylethylene carbonate (VEC), an important component of the non-aqueous electrolyte which is decomposed by reduction faster than the solvent at a slightly more noble potential than 0 V (Li/Li^+). Since the unsaturated bond is prone to polymerization, VEC undergoes a chain reaction on the negative electrode and rapidly forms a close and strong film on the negative electrode surface. This film serves as a physical barrier which inhibits the contact of solvent molecules around lithium ions with the negative electrode, thereby suppressing the reductive decomposition of the cyclic carboxylic acid ester on the negative electrode (see page 5, lines 18-25). As previously explained and demonstrated, the presence of LiBF_4 and LiPF_6 in a molar ratio of 1:9 to 9:1 in the solute (as recited in claim 14) improves cycle characteristics of the battery and decreases the amount of gas generated, and also results in favorable capacity maintenance rate and cycle life.

Takami teaches a mixed non-aqueous solvent which contains γ -butyrolactone (GBL) as a main component, combined with a cyclic carbonate such as propylene carbonate (PC), ethylene

carbonate (EC), or vinylene carbonate (VC). However, Takami does not teach that the solvent may comprise VEC, or that the solvent must contain VEC in addition to a cyclic carboxylic acid ester (A) and a cyclic carbonic ester having no carbon-carbon unsaturated bond (C) as claimed.

In contrast, Mita is directed to a non-aqueous electrolytic solution for capacitors. According to Mita, VEC may be used as one of the main solvents for the electrolyte, which is not decomposed during charge and discharge. Mita provides a long list of exemplary solvents, including EC, PC, and GBL. Further, Example 9 of Mita utilizes a mixed solvent containing VEC and PC. However, Mita does not exemplify or suggest a mixed solvent containing components (A), (B), and (C) as in the present invention, nor does Mita teach that the VEC forms a film as in the present invention. As previously explained, at the operating potential of the battery according to the invention, the unsaturated bond in VEC, which is prone to polymerization, undergoes a chain reaction on the negative electrode and rapidly forms a strong film on the negative electrode surface.

The Examiner contends that it would have been obvious to include VEC in the solvent of Takami, which may contains GBL and PC or EC, since Mita teaches VEC and PC in combination. However, Applicants respectfully submit that the combination of components (A) and (B) and (C) as in the present invention results in a battery with properties which would not have been expected based on the prior art as follows.

Cyclic carboxylic acid esters (A) such as lactone solvents (e.g., GBL) have low solidifying points, and their inclusion in a battery would thus be expected to improve the charge/discharge characteristics at low temperature. However, such cyclic carboxylic acid esters also have drawbacks, such as having a higher reductive decomposition potential than cyclic carbonic acid esters (C), and thus being prone to decomposition. Accordingly, the addition of a cyclic carboxylic acid ester (A) to a non-aqueous solvent largely reduces the basic characteristics of the battery, such as its initial charge/discharge characteristics.

Mita discloses that VEC, a cyclic carbonic acid ester (B), may be used in a mixed non-aqueous solvent, such as one including PC (a cyclic carbonic acid ester (C)). As shown in the Second Declaration of Atsushi Ueda Under 37 C.F.R. 1.132 ("Second Ueda Declaration"), filed herewith, a battery using a non-aqueous solvent mixture containing VEC and a cyclic carbonic acid ester (C) exhibited an initial charge/discharge efficiency nearly the same as that of a battery containing only a cyclic carbonic acid ester (C) as the non-aqueous solvent. Specifically, as seen

in the experimental data in the Table of the Second Ueda Declaration, battery (a) contained EC and PC (80:20), cyclic carbonic acid esters (C) which were used in combination to prevent the solvent mixture from solidifying at room temperature. Battery (a) exhibited an initial charge/discharge efficiency of 80%. Considering battery (b), it can be further seen that inclusion of VEC in the non-aqueous solvent (EC:PC:VEC = 75:20:5) only increased the initial charge/discharge efficiency to 85%. From Mita, which uses VEC with a cyclic carbonic acid ester (C) and these results, one skilled in the art would deduce that the effect of VEC is to increase the initial charge/discharge efficiency by about 5%. In other words, based on Mita and these results, when VEC is added to a cyclic carbonic acid ester (C), the initial charge/discharge characteristics are only slightly improved.

However, Applicants' invention exhibits results which would not be expected based on Mita or the prior art of record. As further described in the Second Ueda Declaration, battery (c) was prepared with a solvent mixture containing GBL as a cyclic carboxylic acid ester (A) and PC/EC as cyclic carbonic acid esters (C). Battery (c) exhibited an initial charge/discharge efficiency of only 50%. Accordingly, inclusion of GBL as a cyclic carboxylic acid ester (A) decreased the basic characteristics of the battery by 30% (80% for battery (a) and 50% for battery (c)). The low temperature characteristic improvements obtained by using component (A) could thus not be put into practical use.

Finally, battery (d) was prepared which contained a solvent mixture of GBL (a cyclic carboxylic acid ester (A)), PC, EC (cyclic carbonic acid esters (C)), and VEC in a 50:35:10:5 volume ratio. Surprisingly and unexpectedly, as shown in the Table, the initial charge/discharge efficiency of battery (d) was improved to 83%. Accordingly, the addition of VEC to a battery (c) containing components (A) and (C) in a non-aqueous solvent increased the initial charge/discharge efficiency by 33%. Such results would not be expected based on the proposed combination of Takami and Mita. Rather, since Mita only exemplifies VEC with a component (C), one skilled in the art would only expect a slight increase, such as an increase of 5%, of the initial charge/discharge efficiency by including VEC in the non-aqueous solvent.

In summary, it would not be expected based on Mita, Takami, or their proposed combination that the addition of VEC (B) to a solvent mixture containing components (A) and (C) would significantly improve the initial charge/discharge efficiency, as well as prevent the decomposition of a cyclic carboxylic acid ester (A) due to the formation of a thin film

comprising VEC. Takami does not teach or suggest VEC, and Mita does not teach or suggest VEC in combination with GBL. Further, since the potential during the operation of the capacitor of Mita is different from the potential during the operation of the claimed battery, a film containing VEC would not be formed in the capacitor of Mita. Therefore, the effect of the present invention, due in part to the formation of the VEC-containing coating, would not be exhibited by Mita.

Accordingly, the results exhibited by the present invention would overcome any *prima facie* case of obviousness, were one to be established, and the battery of the present invention comprising a non-aqueous solvent composed of a cyclic carboxylic acid ester (A), a cyclic carbonic acid ester having at least one carbon-carbon unsaturated bond (B) containing VEC, and a cyclic carbonic acid ester having no carbon-carbon unsaturated bond (C) is non-obvious over the proposed combination of Takami and Mita.

For all of these reasons, reconsideration and withdrawal of the § 103(a) rejection are respectfully requested.

Rejection Under § 103(a) Based on Takami in view of Mita and EP '510

Regarding claims 10-11, the Examiner acknowledges that even the combination of Takami and Mita would not teach that the solvent comprises a glime. However, EP '510 allegedly discloses a non-aqueous electrolyte system consisting of a solvent mixture containing ethylene carbonate, g-valerolactone and optionally containing one or more additional solvents selected from other organic carbonates such as glymes. Therefore, the Examiner concludes that in view of the teachings of EP '510, it would have been obvious to one skilled in the art at the time of the invention to use the solvent comprising a glime of EP '510 in the solvent mixture of Takami/Mita. Applicants respectfully traverse this rejection as follows.

As previously explained, even if the proposed combination of Takami and Mita were valid, Applicants' invention demonstrates unexpected results which would overcome any *prima facie* case of obviousness were one to be established. Specifically, it would not be expected that inclusion of VEC in a non-aqueous solvent containing cyclic carbonic acid esters (A) and (C) would dramatically improve the initial charge/discharge efficiency of the resulting battery, as exemplified by the present invention. EP '510 also does not suggest these results, and accordingly, reconsideration and withdrawal of the § 103(a) rejection are respectfully requested.

Rejection Under 103(a) Based on Takami in view of Mita and in view of Kida

Regarding claims 14 and 16, the Examiner acknowledges that even the proposed combination of Takami and Mita does not teach or suggest the claimed molar ratio of both lithium salts. However, Kida allegedly discloses a lithium secondary battery for which it has been reported that the charge/discharge cycle performance can be improved by using both LiPF_6 and LiBF_4 as the electrolytic salts of the non-aqueous electrolyte in a lithium secondary battery. Kida allegedly also discloses a specific example using a mixture of LiPF_6 and LiBF_4 in a molar ratio of 4:1. Accordingly, the Examiner contends that it would have been obvious to one having ordinary skill in the art at the time of the invention to use the specific molar ratio of both lithium salts as taught by Kida in the electrolyte-solvent mixture of both Takami and Mita to improve the charge/discharge cycle performance and the capacity retention ratio. Applicants respectfully traverse this rejection as follows.

Claim 16 has been withdrawn by this amendment, rendering the rejection of claim 16 moot. Regarding claim 14, as previously explained, even if the proposed combination of Takami and Mita were valid, Applicants' invention demonstrates unexpected results which would overcome any *prima facie* case of obviousness were one to be established. Namely, it would not be expected based on the proposed combination of Takami and Mita that inclusion of VEC in a non-aqueous solvent containing cyclic carbonic acid esters (A) and (C) would dramatically increase the initial charge/discharge efficiency. Kida also does not suggest these results, since Kida does not teach or suggest the claimed non-aqueous solvent containing a cyclic carbonic ester which contains VEC. In particular, Kida teaches in paragraph [0016] that exemplary non-aqueous solvents include ethylene carbonate, propylene carbonate, and gamma-butyrolactone, but are preferably mixed solvents including diethyl ether to give good charge/discharge cycle performance. However, Kida does not teach or suggest VEC, nor a solvent which contains, in addition to VEC, a category (A) and a category (C) component. Accordingly, in view of the unexpected results of Applicants' invention, reconsideration and withdrawal of the §103(a) rejection are respectfully requested.

Rejection Under 103(a) Based on Takami in view of Mita and Inoue

Regarding claims 14 and 16, the Examiner acknowledges that even the proposed combination of Takami and Mita does not teach or suggest the claimed molar ratio of both lithium salts. However, Inoue allegedly discloses a non-aqueous secondary battery in which the electrolyte comprises one or more lithium salts. It is allegedly preferred to use an electrolytic solution comprising LiPF_6 and LiBF_4 incorporated in a mixture of organic solvents. The Examiner argues that Example 1 shows the use of an electrolyte comprising LiPF_6 and LiBF_4 in an amount of 0.9 mol and 0.1 mol per liter, respectively. Accordingly, the Examiner contends that it would have been obvious to one having ordinary skill in the art at the time of the invention to use the specific molar ratio of both lithium salts as taught by Inoue in the electrolyte-solvent mixture of both Takami and Mita to improve the charge/discharge cycle performance and the capacity retention ratio. Applicants respectfully traverse this rejection as follows.

Claim 16 has been withdrawn by this amendment, rendering the rejection of claim 16 moot. Regarding claim 14, as previously explained, even if the proposed combination of Takami and Mita were valid, Applicants' invention demonstrates unexpected results which would overcome any *prima facie* case of obviousness were one to be established. Namely, it would not be expected based on the proposed combination of Takami and Mita that inclusion of VEC in a non-aqueous solvent containing cyclic carbonic acid esters (A) and (C) would dramatically increase the initial charge/discharge efficiency. Inoue also does not suggest these results, since Inoue does not teach or suggest the claimed non-aqueous solvent containing a cyclic carbonic ester which contains VEC. In particular, Inoue teaches in col. 12, lines 12-35 that the electrolyte contains at least one aprotic organic solvent such as PC, EC, butylene carbonate, etc., and preferably ethylene carbonate and/or diethylene carbonate. However, Inoue does not teach or suggest VEC, nor a solvent which contains, in addition to VEC, a category (A) and a category (C) component. Accordingly, in view of the unexpected results of Applicants' invention, reconsideration and withdrawal of the §103(a) rejection are respectfully requested.

Rejection Under §103(a) Based on Takami in view of Mita and in view of Hamamoto

Regarding claim 15, the Examiner acknowledges that the proposed combination of Takami and Mita does not disclose that the solvent comprises a derivative of benzene. However, Hamamoto allegedly teaches in the abstract that a non-aqueous electrolytic solution which may

be used for a lithium secondary battery employs a non-aqueous electrolytic solution which comprises a non-aqueous solvent and an electrolyte which contains a biphenyl derivative. In view of these teachings, the Examiner concludes that it would have been obvious to one having ordinary skill in the art at the time of the invention to use the solvent of Hamamoto comprising a derivative of benzene in the solvent mixture of Takami and Mita, as Hamamoto teaches that by using the benzene derivative as a solvent, a non-aqueous electrolytic solution which is favorably employable for a lithium secondary battery and which shows high battery performance, such as high electric capacity and high cycling performance, under maximum operation voltage condition or elevated temperature is obtained. Applicants respectfully traverse this rejection as follows.

As previously explained, even if the proposed combination of Takami and Mita were valid, Applicants' invention demonstrates unexpected results which would overcome any *prima facie* case of obviousness were one to be established. Hamamoto also does not suggest these results, since Hamamoto does not teach or suggest the claimed non-aqueous solvent containing a cyclic carbonic ester which contains VEC. In particular, Hamamoto in paragraph [0018] teaches that the non-aqueous solvent preferably comprises a combination of a cyclic carbonate and a linear chain carbonate, a high dielectric constant solvent such as ethylene carbonate, propylene carbonate, or butylene carbonate, and a low viscosity solvent, such as γ -butyrolactone or dimethyl carbonate, for example. However, Hamamoto does not teach or suggest VEC, nor a solvent which contains, in addition to VEC, a category (A) and a category (C) component. Accordingly, in view of the unexpected results of Applicants' invention, reconsideration and withdrawal of the §103(a) rejection are respectfully requested.

In view of the preceding amendments and remarks, Applicants respectfully submit that all of the pending claims are patentably distinct over the prior art of record and in condition for allowance. A Notice of Allowance is respectfully requested.

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Respectfully submitted,

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(Date)

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Encl: Petition for Extension of Time (one month)
Second Declaration of Atsushi Ueda Under 37 C.F.R. § 1.132